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UK CL (Edition O) G4H HNEC HNEE HNEL HNEM
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(54) Wide area control system

(57) A control system comprises a control centre which broadcasts control signals and receiving equipment which initiates control of devices. The communications medium may be a radiopaging network or a radio data network. Controlled devices may be associated with energy and may include gas and electricity meters, gas and electricity usage, electricity generation, combined heat and power plants, heating, refrigeration, ventilation and air-conditioning. Broadcast data may include energy price and meteorological data.

Storage heating may be fitted with automatic controls to optimise heating and energy use. Automated controls may be used with other devices to reduce the cost of energy used. Meter readings and other data may be returned via separate communications systems.

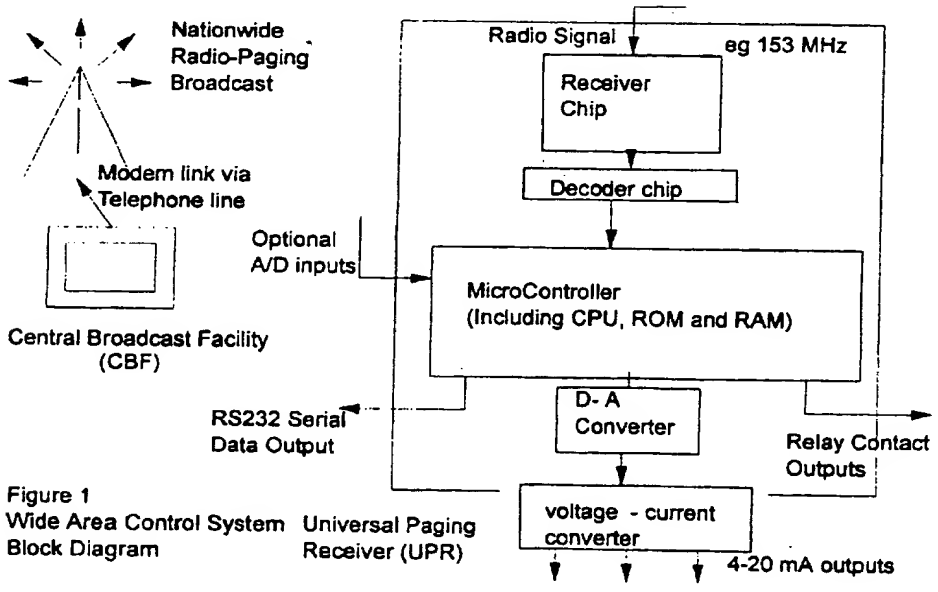

Figure 1
Wide Area Control System Block Diagram

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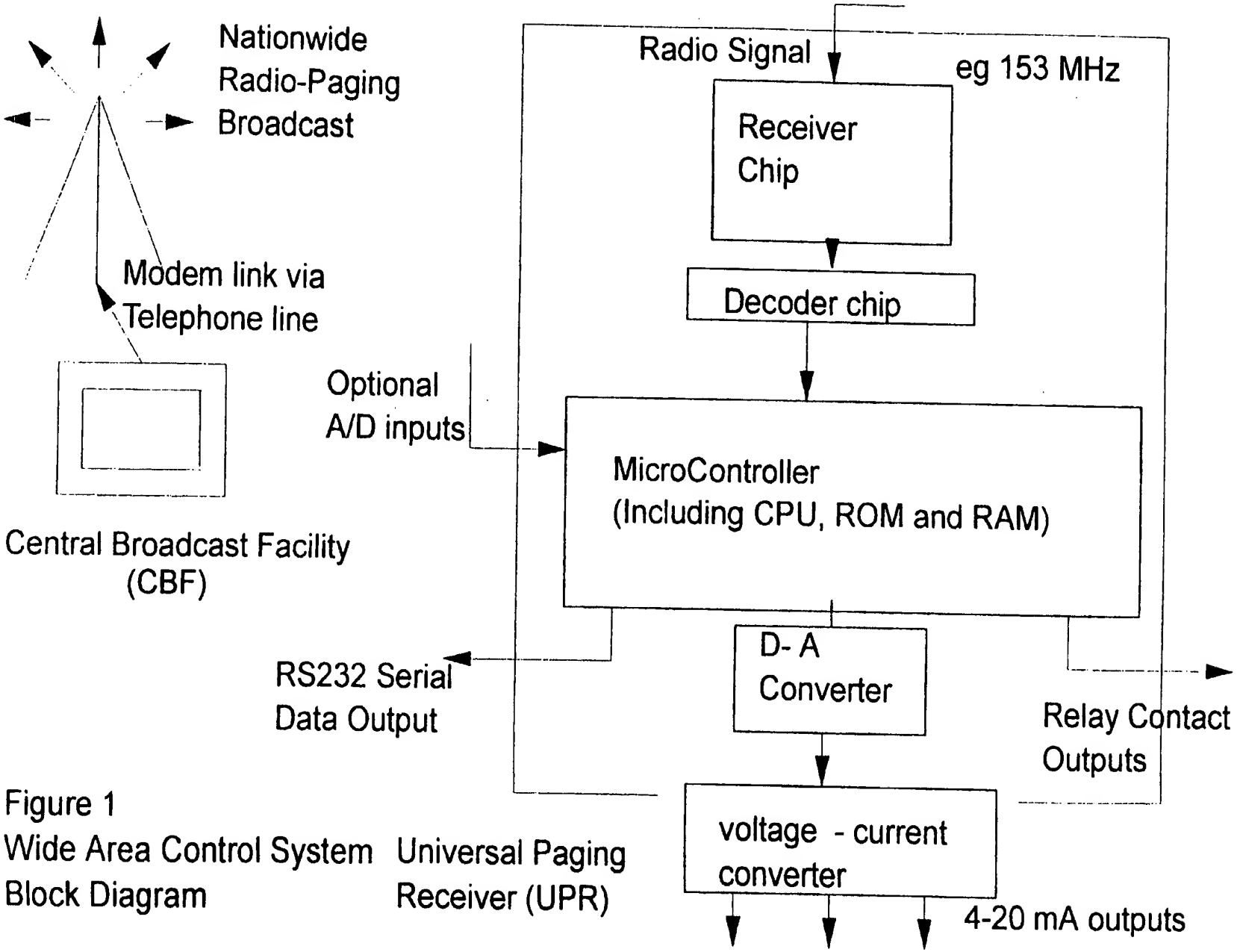
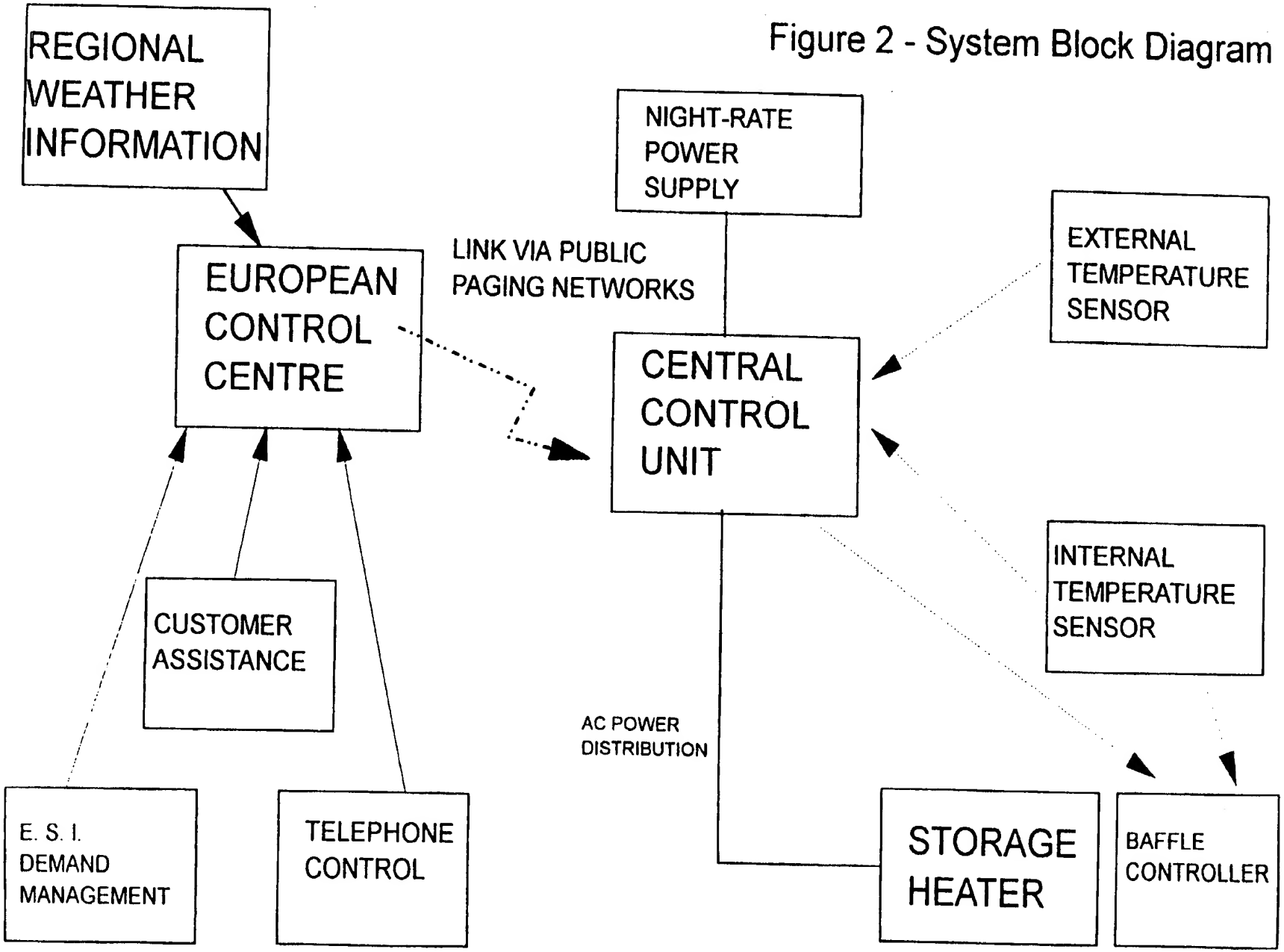


Figure 1
Wide Area Control System Block Diagram

Figure 2 - System Block Diagram



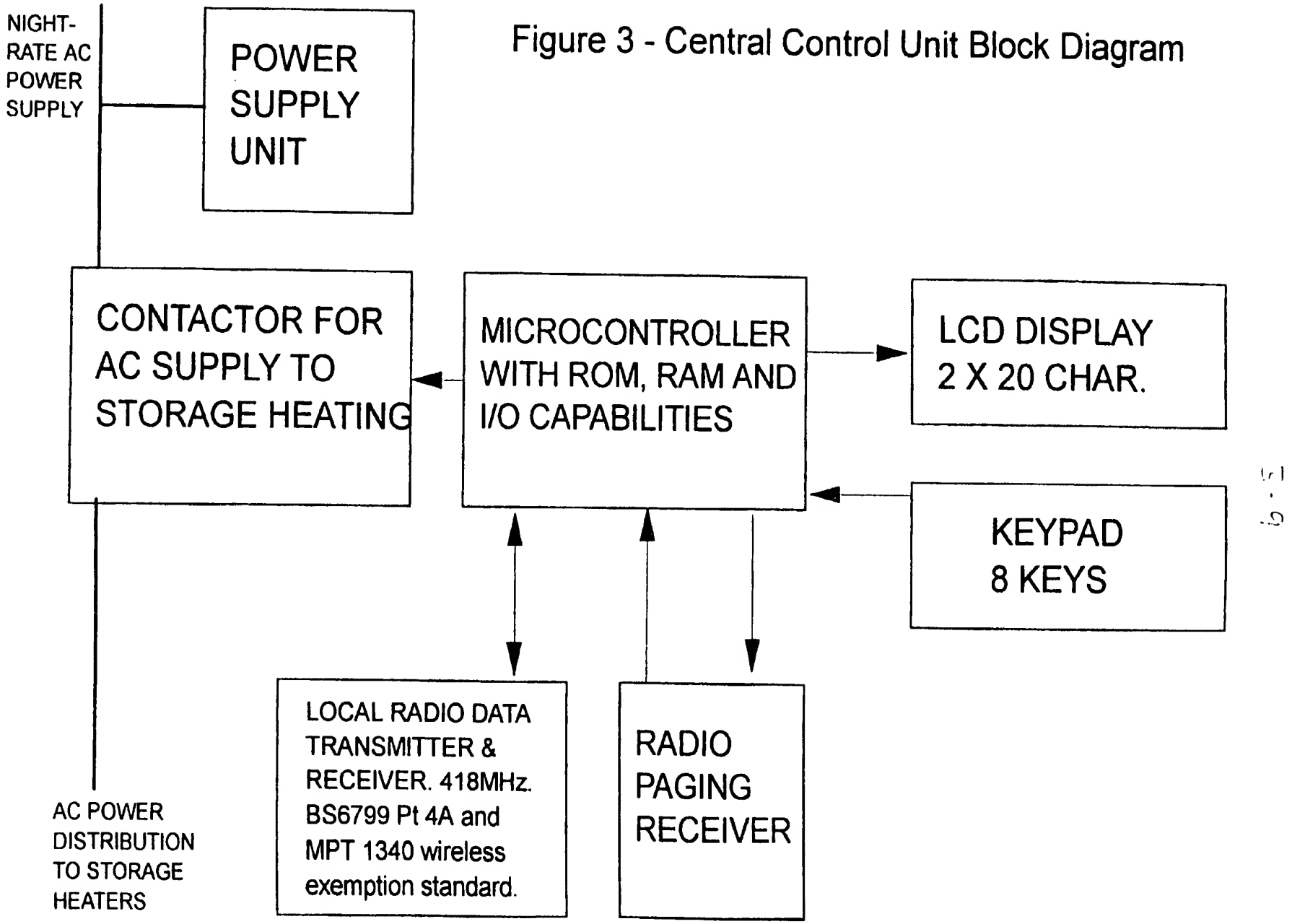
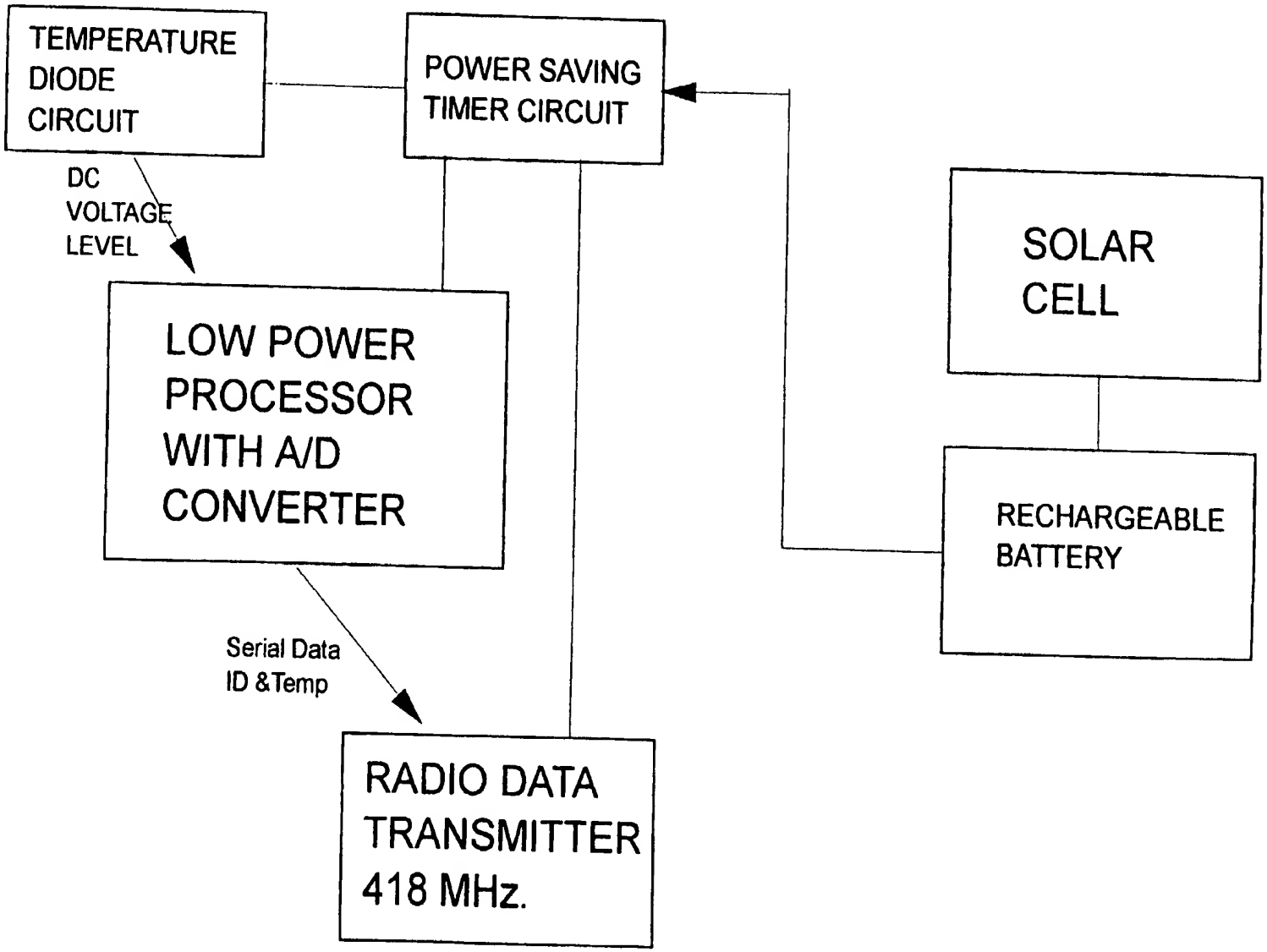


Figure 3 - Central Control Unit Block Diagram

Figure 4 - Temperature Sensor Block Diagram



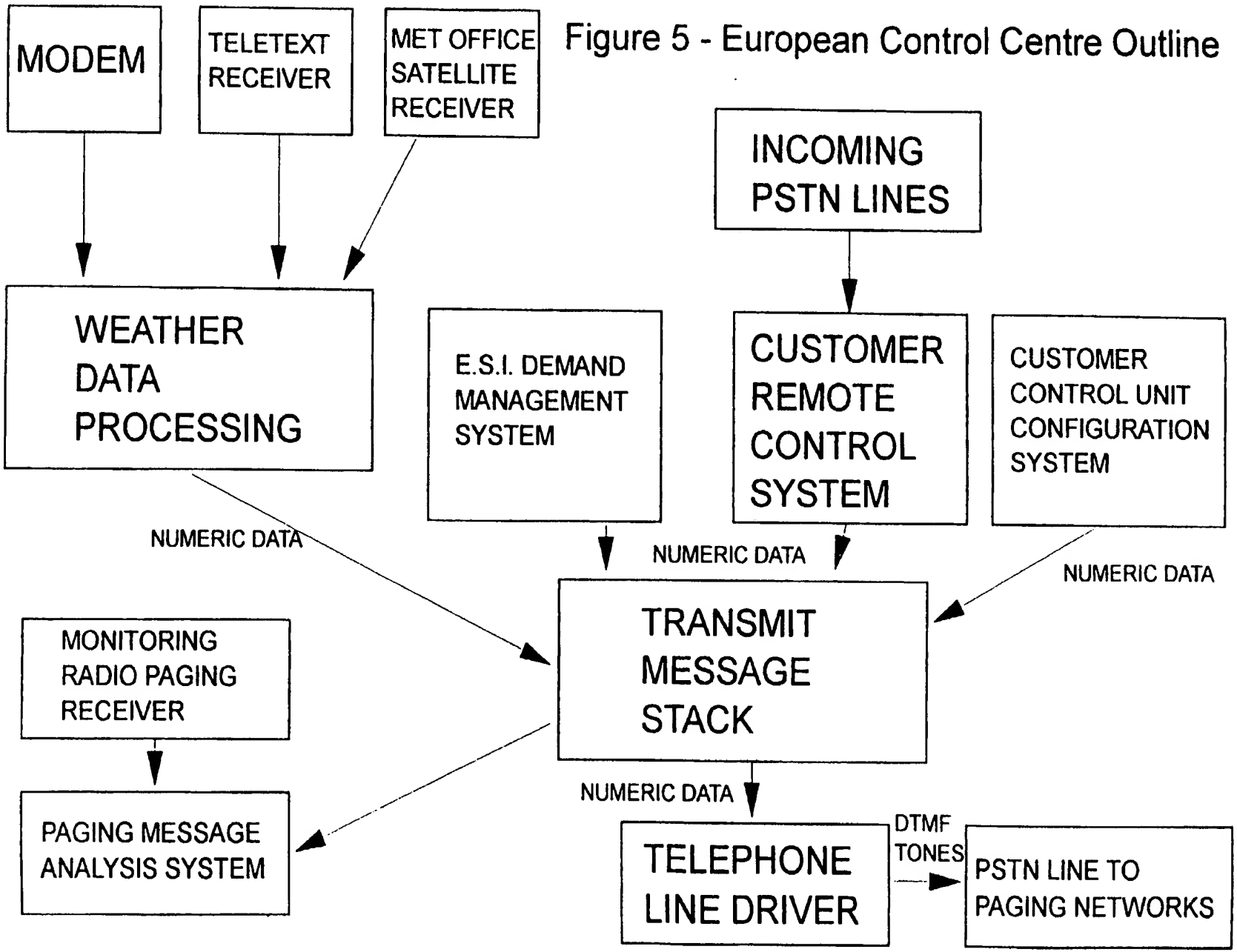


Figure 5 - European Control Centre Outline

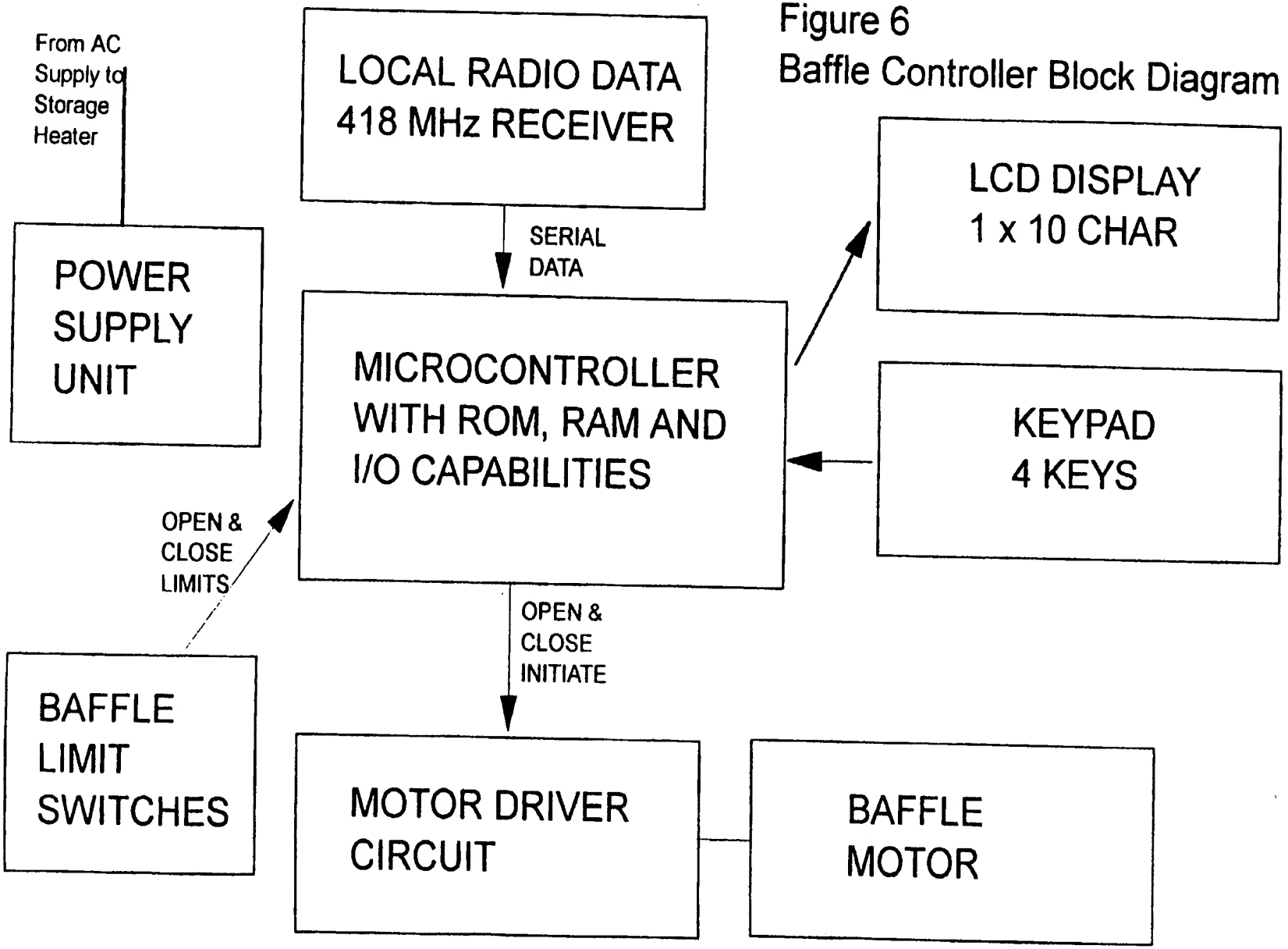


Figure 6
Baffle Controller Block Diagram

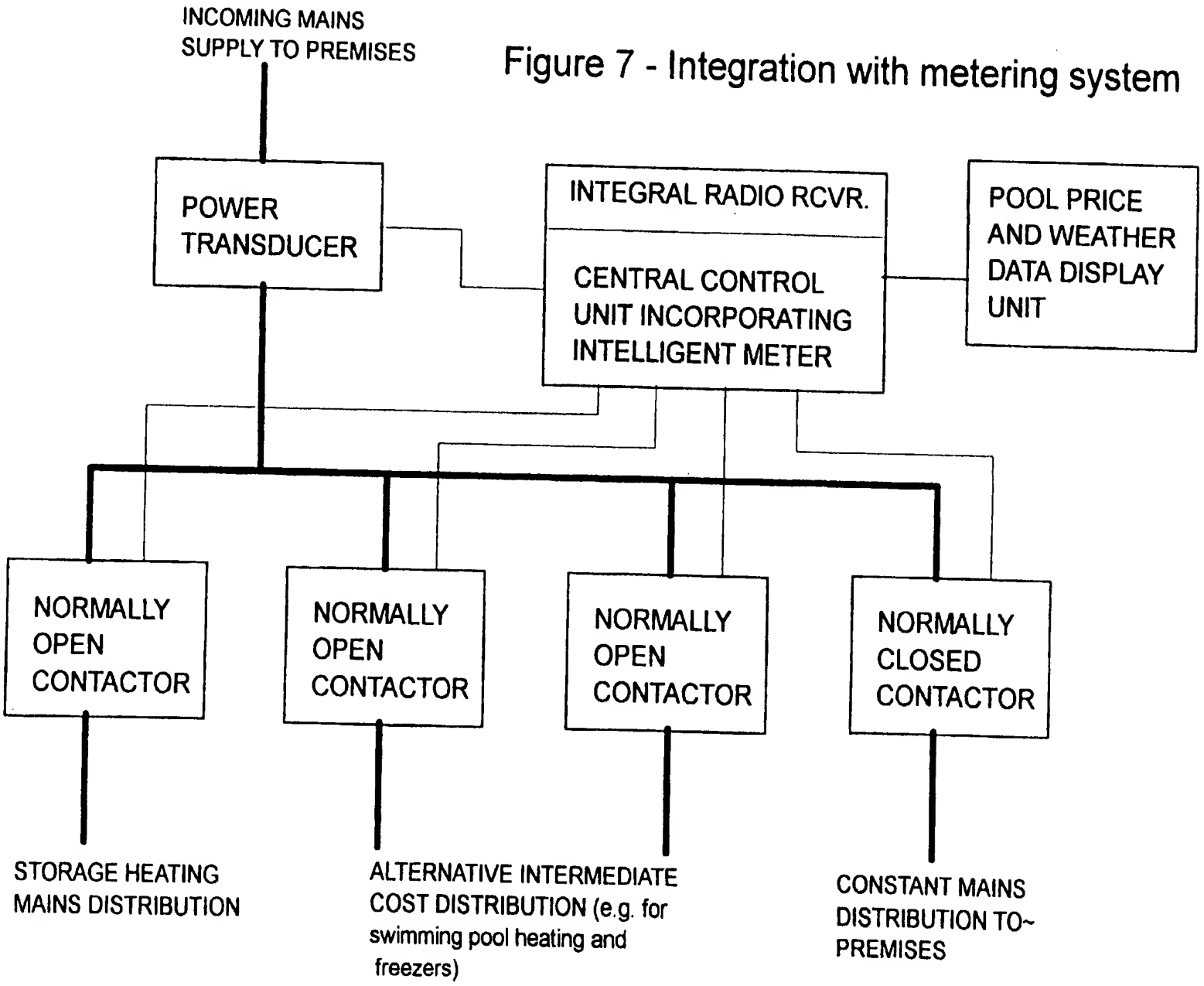


Figure 7 - Integration with metering system

Figure 8 - Public Radio Data Network Generation Control

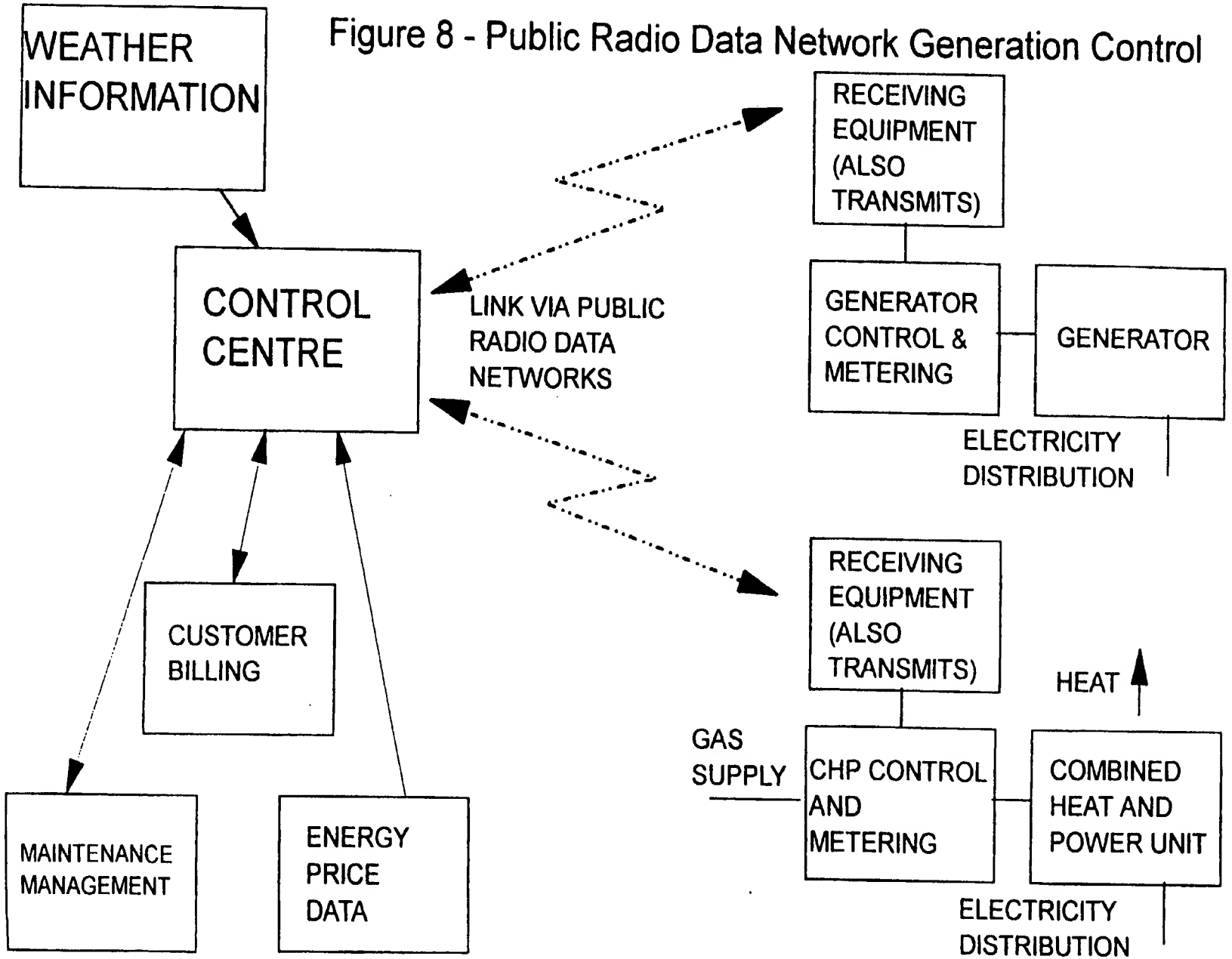


Table 1 - Temperature Control System Variables

Variable	Variable Description	Source	Units	Adjust	Range	Tx Chr No	Typical	Code	Input Variables
GA	Geographical Area	Xmit	N/A	N/A	00-50 *(3)	1,2	Suffolk	02	
T1	Mean Temperature Forecast	Xmit	Deg C	- 20	00-89,99 *(4	3,4	6 Deg	26	
T2	Min Temperature Forecast	Xmit	Deg C	- 20	00-89,99 *(4	5,6	3 Deg	23	
T3	Max Temperature Forecast	Xmit	Deg C	- 20	00-89,99 *(4	7,8	8 Deg	28	
WS	Mean Wind Speed Forecast	Xmit	m/s	* 3	0-9	9	4 m/s	1	
WD	Wind Direction Forecast	Xmit	Degrees	*45 *(1)	0-7,9	10	Variable	9	
SL	Hours Sunlight Forecast	Xmit	Hours	None	00-15,99 *(4	11,12	Not known	99	
HY	Humidity Forecast	Xmit	Percent	None	01-99,00 *(5	13,14	75 %	75	
TC	Compensated Temp. Forecast	Xmit	Deg C	- 20	00-89,99 *(4	15,16	5 Deg	25	
ON	Calculated On Period	Xmit	mins x 10	None	00-42,99 *(4	17,18	3 Hrs	18	
TT	Transmitted Time	Xmit	Hrs/Mins	(24 Hr)	XX:XX	3-6 *(2)	11:53	1153	
ERR	Error Check	Xmit	N/A	N/A	00-99 *(6)	19,20	94	94	GA,T1,T2,T3,WS,WD,SL,HY,TC,ON (GA,TT) *(6)
AA	Area	Keypad	N/A	N/A	01-49	N/A	Suffolk	02	
RT	Required Temperature	Keypad	Deg C	- 20	00-99	N/A	21 Deg	41	
DS	Susceptibility to Draughts	Keypad	None	N/A	0-3	N/A	Draughty	2	
DW	Particular Wind Direction	Keypad	Degrees	* 45	0-7,9	N/A	Easterly	2	
TI	Internal Temperature	Sensor	Deg C	- 20	00-99	N/A	17 Deg	37	
TE	External Temperature	Sensor	Deg C	- 20	00-99	N/A	5 Deg	25	
SS	Supply Live	Supply	Off/On	N/A	0,1	N/A	On	1	
EX	Econ. 7 Externally Switched	Keypad	No/Yes	N/A	0,1	N/A	No	0	
ET	Econ. 7 Start Time	Keypad	Hrs/Mins	(24 Hr)	XX:XX	N/A	23:05	2305	
EF	Econ. 7 Finish Time	Keypad	Hrs/Mins	(24 Hr)	XX:XX	N/A	05:55	0555	
MO	Mode of Operation	Keypad	Off .. E7 *(7	N/A	0-3	N/A	Auto	2	
OP	On Period (Last Night)	Memory	mins x 10	None	00-42	N/A	2 Hr 30 mn	15	OA
OQ	On Period (Night Before)	Memory	mins x 10	None	00-42	N/A	5 Hr 10 Mn	31	OP
EL	Econ. 7 Live	Calc.	No/Yes	N/A	0,1	N/A	No	0	SS,EX,ET,EF,TM
TL	Locally Compensated Temp	Calc.	Deg C	- 20	00-99	N/A	4 Deg	24	T1,T2,T3,WS,WD,SL,HY,RT,DS,DW,TI,TE,OP,OQ
OA	Actual On Period	Calc.	mins x 10	None	00-42	N/A	3 Hr 20 Mn	20	TL
ER	Econ. 7 Period elapsed	Calc.	mins x 10	None	00-42,99	N/A	N/A	99	EL,TIMER
TM	Time	Timer	Hrs/Mins	(24 Hr)	XX:XX	N/A	12:47	1247	TT,TIMER
CS1	Contactor Start Time 1 (ref. ER)	Calc.	mins x 10	None	00-42,99	N/A	10 mins	01	OA,ET,EF
CP1	Contactor Stop Time 1 (ref. ER)	Calc.	mins x 10	None	00-42,99	N/A	1Hr 20Mn	08	OA,ET,EF
CS2	Contactor Start Time 2 (ref. ER)	Calc.	mins x 10	None	00-42,99	N/A	4Hr 30Mn	27	OA,ET,EF
CP2	Contactor Stop Time 2 (ref. ER)	Calc.	mins x 10	None	00-42,99	N/A	6Hr 40Mn	40	OA,ET,EF
CC	Contactor Close Output	Calc. O/P	Off/On	N/A	0,1	N/A	Off	0	SS,MO,EL,ER,CS1,CP1,CS2,CP2

Notes

1] WD has values 0-7 for directions N through to NW. Value 9 for undetermined.
2] Time is sent as part of a separate transmission to all areas with Error Check in 7,8
3] GA values: 00 - All Areas; 01-49 Individual Areas; 50 Time Broadcast
4] Where data is unavailable code 99 is sent
5] Where data is unavailable code 00 is sent
6] Error Check = (100 - (sum (characters 1..18))mod 99) mod 100
7] Modes of Operation: 0 - Off always; 1 - On 24 Hrs; 2 - Automatic; 3 - Full E7 Period

WIDE AREA CONTROL SYSTEM

DESCRIPTION CONTENTS

1.0] System Overview

A wide area control system allows control of devices associated with receiving equipment from a control centre. Communication may be by radio, radiopaging, two-way radio data networks. It is possible that there is more than one control centre and probable that there are a number of receiving sites.

A radiopaging network may be used to transmit data. A message addressed to a single pager may be broadcast by all transmitters associated with a radiopaging network, the signal being received by all receivers. Control centres may be connected to the radio paging networks via the public telephone network. Radiopaging broadcasts may be received by all receivers. The control signals may be encoded to determine the response of a specific receiver's associated controlled devices. Figure 1 shows a control system featuring a control centre (labelled as a Central Broadcast Facility) and a single receiving device with control outputs which may be connected to controlled devices. Use of radiopaging networks in this manner is described below with specific reference to control of storage heaters and electricity meters.

A wide area control system may be used to initiate the return of data over a different communications network or circuit, for example a telephone line. A specific example described below, involves the use of control data broadcast over the radiopaging network initiating return of meter reading data via a modem and telephone line.

A radio data network may be used to transmit data. Control data may be addressed to specific receivers. Control data to be received by more than one receiver may be broadcast more than once. Radio data networks are bi-directional and therefore data maybe returned from the controlled devices via the receiver to the control centre. Use of radio data networks in this manner is described below with specific reference to control of generators.

There are many applications for a wide area control system, non-limiting examples of equipment associated with receiving devices are:

Gas using equipment
Gas meters
Electricity using equipment
Electricity meters
Electricity generators
Heating equipment
Refrigeration, ventilation and air-conditioning equipment

In electric storage heating applications one of the purposes of the wide area control system is to overcome the inflexibility and lack of control in conventional storage heating systems. With a wide area control system the level of overnight charging of the storage heaters is controlled based on variable parameters such as the weather forecast or by optional local temperature sensors. Room temperatures may also be controlled by automatic control of the baffles within the storage heaters.

In storage heating applications a Central Control Unit may be connected so that it can switch the power supply to all the storage heaters in the system. System Block Diagram Figure 2 should be referred to. The Central Control Unit has a radio receiver that periodically receives weather data. The storage heaters may be switched on for a duration determined by the Central Control Unit. This duration may be calculated automatically based on variable parameters such as the weather forecast or local temperature data as well as user settings.

The longer the heaters are switched on, the more they are charged up. When the forecast is for cold weather the heaters will be on for a long period (up to the full cheap-rate period). Conversely when the forecast is for warmer weather the heaters will be on for shorter periods. The individual heater input controls will be set high as the charging level is determined by the Central Control Unit.

Additional control is achieved by automatic operation of the storage heater baffles. The baffle is a vent that controls the rate at which a storage heater gives its heat off to the room. When the baffle is opened more air can pass the heat storage bricks, and hence more heat is given out to the room. By fitting a remote controlled baffle to the storage heater, the heater output can be varied. This allows the room temperature to be accurately controlled throughout the day.

The weather forecast information is preferably broadcast. Preferably the weather forecast information is broadcast from the Control Centre via radio. This will preferably be via the public radio paging network. Forecasts are broadcast for each geographic region, so that all homes receive a forecast relevant to their area. The Control Centre may also broadcast to each Central Control Unit individually or in groups. This gives additional operational facilities, including assisting users with programming their Central Control Unit.

This additional control facility also provides an *Electricity Demand Control* facility. This will allow demand for electricity to be varied by thousands of megawatts. This control facility is very valuable as bulk electricity is traded in a volatile market. It is also a useful tool for raising the base load of the electricity supply network. The level of available demand control is determined by the number of homes with wide area control equipment and the amount of heating required by them.

Generation may also be controlled. Electricity generators may be switched on when electricity prices are high and switched off again when prices are lower. Operational data, electricity or gas meter readings data and maintenance data may be retrieved via a radio data network. This data may also be retrieved via an alternative communications channel, such as a telephone line.

Control of many small generators would give simultaneous control of a large amount of generation, thus giving an *Electricity Supply Control* facility. This control has a similar value, as supply can be varied to meet demand, and also generation can be made to run only when profitable.

By integrating the Central Control Unit, in the storage heating application, with the metering system electricity may be metered with variable unit price which may enable a new range of electricity supply contracts.

Wide Area Control System

By sending paging signals to equipment individual systems of other types may be controlled singularly or in groups.

The system may further be developed so that the following are possible:

Control and Metering of Gas or Water Systems
Reading of meters, which may be by a remote method using the customer's telephone line

These possibilities are discussed further below.

Wide Area Control System

2.0] Control System Applications

A nation's electricity supply system operates most efficiently when power consumption remains constant throughout the day. Unfortunately demand varies considerably over a 24-hour period as factories normally operate in the day, homes need lighting and heating during mornings and evenings and relatively little power is needed at night. So that this demand pattern can be flattened somewhat the Electricity Supply Industry has encouraged the installation of storage heaters by offering cheaper electricity at night.

Non-limiting applications of the invention are outlined below:

2.1] Gas metering

Control data may be broadcast to gas meters. This data may be broadcast over a radiopaging network or a public radio data network, such as the *Paknet* system in the United Kingdom. Control data may include gas price. The gas meter may calculate the cost of gas use. The gas meter reading data may be read over the radio data network or an alternative communications channel such as a telephone line.

2.2] Gas use

Control data may be broadcast, such as forecast temperature data or gas price data, enabling control of gas using equipment. The data may be used by a heating system to ensure a building is at the required temperature, or to ensure that gas use is minimised if gas becomes expensive.

2.3] Electricity metering

Control data may be broadcast to electricity meters. This data may be broadcast over a radiopaging network or a public radio data network, such as the *Paknet* system in the United Kingdom. Control data may include electricity price data or tariff data. The electricity meter may calculate the cost of electricity use. The electricity meter reading data may be read over the radio data network or an alternative communications channel such as a telephone line.

2.4] Electricity generation

Control data may be broadcast to an electricity generator. This data may be broadcast over a radiopaging network or a public radio data network, such as the *Paknet* system in the United Kingdom. Control data may include electricity price data or tariff data. The generator may operate when electricity prices are high, but not when prices are lower. Data such as operational data, metering data or maintenance data may be retrieved. This data may be read over the radio data network or an alternative communications channel such as a telephone line. Figure 8 shows a generator control system where the broadcast medium is a radio data network.

2.5] Electricity use

Control data may be broadcast, such as forecast temperature data or electricity price data, enabling control of electric equipment. The data may be used by a heating system to ensure a building is at the required temperature, or to ensure that electricity use is minimised if electricity becomes expensive. Loads which do not have to be constantly energised may be switched off to minimise electricity charges.

2.6] Heating Systems

Control data may be broadcast, such as forecast temperature data or energy price data, enabling control of heating equipment. Heating equipment may include space heating equipment, process heating equipment and boilers. The data may be used by a heating system to ensure a building is at the required temperature, or to ensure that energy use is minimised if energy becomes expensive. Loads which do not have to be constantly energised may be switched off to minimise fuel charges. Where heating equipment is used to maintain a substance or a room within a required temperature range a control algorithm may be used which ensures that expensive energy is used only when the controlled temperature approaches its lower limit and that only cheaper energy is used to achieve the upper limit. This control algorithm reduces energy cost.

2.7] Storage Heating Systems

A storage heater consists of an electric element that heats up a brick heat-storage core overnight. The core and element are fitted in an insulated housing that has a vent in the top. There is a baffle which can be operated so that the bricks can discharge their heat more rapidly to the room. Heat is discharged to the room all the time through the thermal insulation of the heater. The rate of discharge reduces as the stored heat decays.

The heater is usually fitted with two controls an *input* control and a *boost* control. The *input* control is variable and controls how much the storage bricks are charged and hence also how much electricity is used over the cheap-rate period. The *boost* control is also variable and controls the baffle to allow additional heat discharge to the room. This is normally used in the evening as the storage bricks are cooler following a day of discharging.

The storage heaters are generally connected to a separate power supply fed by an automatic switch which energises the heater supplies during the cheap-rate period.

A wide area control system may be used to ensure that the heaters only receive the amount of charging required for the following day's heating needs. It can may be used to ensure that storage heaters are energised when electricity is at its cheapest. An example of such a system is shown in Figure 2.

Wide Area Control System

2.8] Combined Heat and Power Systems

Control data may be broadcast to control Combined Heat and Power systems which provides useful heat and also generate electricity. This data may be broadcast over a radiopaging network or a public radio data network, such as the *Paknet* system in the United Kingdom. Control data may include electricity price data, tariff data or similar gas data. The generator may operate when electricity prices are high, but not when prices are lower. Generation may also be dependent on gas prices. Data such as operational data, metering data or maintenance data may be retrieved. This data may be read over the radio data network or an alternative communications channel such as a telephone line. Figure 8 shows a generator control system where the broadcast medium is a radio data network.

2.9] Refrigeration Systems

Control data may be broadcast, such as forecast temperature data or energy price data, enabling control of refrigeration equipment. The data may be used to ensure that energy use is minimised if energy becomes expensive. Where refrigeration equipment is used to maintain a substance or a space within a required temperature range a control algorithm may be used which ensures that expensive energy is used only when the controlled temperature approaches its upper limit and that only cheaper energy is used to achieve the lower limit. This control algorithm reduces energy cost.

2.10] Ventilation and Air-Conditioning Systems

Control data may be broadcast, such as forecast temperature data or energy price data, enabling control of ventilation and air-conditioning equipment. The data may be used to ensure that energy use is minimised if energy becomes expensive. Where equipment is used to maintain a room within a required temperature range a control algorithm may be used which ensures that expensive energy is used only when the controlled temperature approaches its upper limit and that only cheaper energy is used to achieve the lower limit. This control algorithm reduces energy cost.

2.11] General Control

A general control system may be provided, where radiopaging signal receivers are used to control equipment, with serial, analogue or relay-contact interfaces. A microcontroller with the receiver assembly may process received and other input signals and control signal outputs to local devices in response to these input signals. Such an arrangement is shown in Figure 1.

3.0] Principles of the Wide Area Control System

The invention will now be described with reference to non-limiting embodiments. It will be apparent to one of skill in the art that the invention could be implemented in alternative ways.

A radiopaging network may be used to transmit data. A message addressed to a single pager may be broadcast by all transmitters associated with a radiopaging network, the signal being received by all receivers. Control centres may be connected to the radio paging networks via the public telephone network. Radiopaging broadcasts may be received by all receivers. The control signals may be encoded to determine the response of a specific receiver's associated controlled devices. Figure 1 shows a control system featuring a control centre (labelled as a Central Broadcast Facility) and a single receiving device with control outputs which may be connected to controlled devices. Use of radiopaging networks in this manner is described below with specific reference to control of storage heaters and electricity meters.

A wide area control system may be used to initiate the return of data over a different communications network or circuit, for example a telephone line. A specific example described below, involves the use of control data broadcast over the radiopaging network initiating return of meter reading data via a modem and telephone line.

A radio data network may be used to transmit data. Control data may be addressed to specific receivers. Control data to be received by more than one receiver may be broadcast more than once. Radio data networks are bi-directional and therefore data maybe returned from the controlled devices via the receiver to the control centre. Use of radio data networks in this manner is described below with specific reference to control of generators.

In storage heating applications the wide area control system may be based on weather data radio transmissions to Central Control Units in domestic properties. Data transmission may be via national radio paging systems such as British Telecom's EasyReach system.

Weather information is collated at the Control Centre and a numeric data string is compiled from the weather information. The string contains details of forecast temperature, wind-speed, humidity and applicable geographic region. Details of transmitted variables are shown in Table 1 'Temperature Control System Variables'. The data is transmitted down a standard telephone line by dialling the digits shown below. The dialled parameters are detailed in the table. Dialling would normally be performed automatically by a PC fitted with a modem.

PPPPP IIIIII ^^^^ ddddddddddddddddddd
e.g. 01426 609658 ^^^^ 02262328199975251894

Parameter	Coding	Example
Paging Network Access Number	PPPPP	01426
Individual Paging Number used by *Wide Area Control*	IIIIII	609658
Pause required to allow connection to Paging Network	^^^^	8 seconds typically
Weather data string (20 digits)	ddddddddddddddddddddd	2262328199975252000

The Central Control Unit is fitted with a radio receiver that passes all received weather data strings to its integral microcontroller for further processing. It is anticipated that there will be approximately three daily weather data transmissions for each geographic region. This means three calls per region *not* three calls per Central Control Unit. This system differs from a conventional paging system in that many receivers take data from a single transmission. There will be further transmissions for Electricity Supply Industry demand management, time setting and customer individual services.

The Central Control Unit calculates the length of time to switch on the charging circuits to the storage heaters based on a number of parameters. The table below lists the probable key parameters and details their source.

Parameter	Source
Forecast Temperature	Paging Transmission
Forecast Windspeed	Paging Transmission
Outdoor Temperature	Local Sensor (Optional)
Indoor Temperature	Local Sensor (Optional)
Required Temperature	Central Control Unit Keypad

System performance is enhanced by adding indoor and outdoor temperature sensors. Further control is achieved by fitting automatic baffle controls. A motor driven baffle will be fitted to relevant storage heaters. This will be controlled with a local temperature sensor to maintain the required room temperature.

Control Information to and from this local equipment will be transmitted using low power 418MHz radio communications to the UK approved MPT1340 standard. All equipment operates from rechargeable batteries which are charged either by solar cells or by the existing mains supply (which is not available during the day). This approach minimises cable use and battery replacement. This in turn reduces installation and maintenance costs.

Wide Area Control System

4.0] Consumer Benefits of System

Firstly a Simple Wide Area Control System with heater charging only is discussed. Secondly an Advanced Wide Area Control System with the addition of automatic baffle control is considered. The systems will be produced in such a way that it will be possible to upgrade from a Simple to an Advanced system.

A nation's electricity supply system operates most efficiently when power consumption remains constant throughout the day. Unfortunately demand varies considerably over a 24-hour period as factories normally operate in the day, homes need lighting and heating during mornings and evenings and relatively little power is needed at night. So that this demand pattern can be flattened somewhat the Electricity Supply Industry has encouraged the installation of storage heaters by offering cheaper electricity at night.

4.1] Benefits

With the addition of a Simple Wide Area Control Unit the consumer gains the following:

Additional Comfort

The Control Unit gives the heaters a greater charge when cold weather is expected giving plenty of warmth on cold days. Without the controller the house would become a lot colder and uncomfortable. Conversely when warm weather is expected the heaters charge is lower so that the house does not become to hot. Without the controller the house would become hot and uncomfortable.

Cost Savings

In warm weather the Control Unit charges the heaters less so that less electricity is required to charge them up. Without a Control Unit the heaters could charge up to much, windows would have to be opened and valuable heat (and money) would be thrown away. In cold weather the heaters would not charge enough. This would mean that additional expensive heating may be required during the day. Clearly a Simple Wide Area Control System would give significant fuel cost savings.

Stylish Control Unit

A stylish control unit is easily installed by a local electrician or by our field engineer. With its reliable microcontroller it can provide the following information at any time:

Time and Date

The time and date are received automatically by Wide Area Control radio transmissions. The time never has to be set and even adjusts itself by an hour when the clocks change.

Regional Weather Forecast

The Regional Weather Forecast for the following day can always be checked by pressing a few keys on the controller. The LCD display shows the forecast temperature, rain and windspeeds.

Power Consumption

The controller can indicate how long the storage heaters have been on for. It can be set up to show how much power has been used, so that electricity charges can be monitored.

Addition of Internal and External Temperature Sensors

These can be added easily to a Simple Wide Area Control System. The external one should be mounted where it is not exposed to wind, rain or direct sunlight. The internal one should be mounted in the living room. These sensors improve the performance of the controller so that the charging time is calculated more accurately. This leads to further gains in comfort and greater cost savings.

Automatic Baffle Controls

An Advanced Wide Area Control System has automatic baffle controls on individual storage heaters. This gives the following:

More Comfort

Instant control of Room temperatures. This means that room temperatures can be kept at exactly the required temperature throughout the day.

Programmable Control. This means that rooms can be programmed to warm up at certain times. (e.g. during the afternoon ready for people arriving home from school and work)

4.2] Comparisons with Conventional Heating Systems

The table below shows how the WIDE AREA CONTROL System compares with other heating systems. It should be noted that the information is qualitative or estimated The star ratings range from * (poor) to ***** (excellent).

	Simple WIDE AREA CONTROL System	Advanced WIDE AREA CONTROL System	Conventional Storage Heating	Conventional Gas Central Heating	Conventional Oil Central Heating
Percentage of Homes Available to	*****	*****	*****	***	***
Fuel Costs	****	****	***	****	****
Home Alterations to install	*****	*****	*****	**	*
Installation Costs	****	****	*****	**	*
Maintenance Costs	****	****	*****	***	*
Overall Costs	*****	****	***	***	***
Comfort	***	****	*	****	****
Additional Features	****	*****	**	**	**

It can be seen that the Wide Area Control System has a number of competitive advantages over other heating systems.

·It can be installed in more than 98 % of all homes (those within Paging Network range). Gas Central Heating can only be installed where there is mains gas. Oil fired heating can only be installed where the premises have space for an oil tank.
·It costs less to install than Gas or Oil Central Heating.
·It has no unsightly pipes or tanks and no boiler.
·There is no annual inspection and maintenance charge. No oil deliveries to arrange.
·Cheapest Running Costs.
·More comfortable than Conventional Storage Heating.
·Additional advanced Time, Weather and Power Use Display Features.

4.3] Additional Consumer Services

The Wide Area Control System will have the following additional features. (These may be provided optionally with an additional charge)

Customer Service Centre Support

Each Control Unit will have a unique identification number. This number will enable the Customer Control Centre to program and adjust the customer's Control Units remotely. This means that initial installation and later programming can be assisted by the Control Centre. It will also allow remote testing of the unit. This facility will:

- Improve customer service
- Improve the performance of the product
- Reduce servicing and maintenance costs

Telephone Control (Advanced System with Baffle Control)

This service will allow control of the individual heating system from any standard telephone. The customer can ring a number and can then enter a unique code identifying his heating system. The customer can then adjust his heating system remotely from the telephone keypad. The settings would then be passed on via the Wide Area Control radio system.

- He could increase heating if he was expecting to return home unexpectedly on a cold day.
- He could decrease heating if he was expecting to be away for some time.

This feature therefore enhances comfort still further and can lead to more electricity savings.

4.4] Electricity Supplier Benefits

Integration with Electricity Meter and Time-Switch

The Wide Area Control system can be extended to integrate a premises' electricity meter and outgoing distribution circuits. This arrangement is shown on block diagram Figure 7. This integration will allow system development so that the following can be provided Pool price will be broadcast by the Radio system as will load start and shed signals for the varying supply types.

New customer supply contract types

Currently smaller customers have a choice of two types of supply. Standard (which is charged at a standard rate per unit, whenever it is used) and Economy 7 (which is charged at a much lower fixed rate, but is only over a fixed period during the night). The WIDE AREA CONTROL system allows this limited product range to be expanded by addition of the following features:

Broadcast of price means that the meter can charge for electricity at the current price. This price could vary frequently, and the meter would tally accumulated cost as well as accumulated electricity use. Accumulated cost would be calculated automatically using broadcast price data. Rates can also be broadcast. (e.g. a weekend price and a weekend start signal).

Switching of Interruptable Loads means that loads which do not have to be on all the time can be switched off when bulk electricity is expensive and switched back on when electricity is cheap. The period for which it is acceptable to switch a load off is dependant on the load. Freezers may be switched off for up to an hour, Swimming pools for 3 hours, Storage heaters 15 hours etc.

Remote changing of tariff structure means that a customer can change their supply contract instantaneously, with change signals being sent from the European Control Centre.

A wide portfolio of supply contracts for customers

The table below shows a range of contracts that could be arranged:

Product Name	Product Description	Electricity Price	Contactor Operation
Pool Price Plus	Electricity at Pool Price	Pool Price + Distribution Mark-up	Programmable by customer to actuate on timers or price thresholds
PPP Capped	Electricity follows Pool Price, Capped to prevent risky cost overruns.	Pool Price + Higher mark-up. Ceiling price (e.g.. 15p/unit)	As above
Standard	Electricity at fixed price	7.0p	N/A
ECON 7	Electricity at two rates. Lower rate is for a fixed seven-hour period`	7.0p high rate 2.7p low rate	At time period changes
ECON 7 (with Wide Area Control)	Electricity at two rates. Lower rate is for a fixed seven-hour period`	7.0p high rate 2.7p low rate	As determined by heating control algorithm and Energy Management signals
EIGHT plus BOOST (with Wide Area Control)	Electricity at two rates. Lower rate is for an eight hour period during the night and an additional two hours in the afternoon (These are determined by the supplier)	7.0p high rate 3.5p low rate	As determined by heating control algorithm and Energy Management signals
TWO out of THREE	Electricity at two rates. Higher rate is constantly available. Lower rate is available for at least 2 Hrs in every 3. Good for Heaters and Air Conditioning.	7.0p high rate 5.0p low rate	As determined by Energy Management signals

Wide Area Control System

More competitive purchase of bulk electricity

By determining when the consumer is supplied with electricity, the supplier can limit the amount of power bought when the price is high and increase the amount bought when the price is low. This means that the average bulk purchase price is reduced.

Matching of demanded electricity to bulk supply contracts

Where bulk electricity is bought through fixed price contracts, the REC can ensure that the total electricity required in peak time-slots is no greater than the amount the REC is contracted to buy. Any additional electricity purchases then take place in time-slots where the electricity is cheaper.

Remote connection and disconnection of supplier premises

If contactors are fitted to switch all of the customer's power, then the supplier will be able to disconnect all supplies remotely if required. Using a normally closed type of contactor would reduce the danger of cutting a customers supply off accidentally.

Automated Billing

The electricity meter may be read remotely by connection to the existing telephone line at the customer's premises. Calls may be generated by the electricity meter to the electricity suppliers telephone number.

The electricity meter or the Central Control Unit may establish the telephone call to the billing centre. Billing data will then be passed over the telephone line from the premises' to the billing centre. Data may also be passed the other way. Billing data may include:

- Customer or equipment unique identity code
- Electricity used
- Cost of Electricity used
- Load profile
- Exact electricity used in particular time slots
- Fault information
- Other information

Initiation of the billing telephone call may be initiated by the following:

- Reaching a certain time (either absolute or since the last call)
- A paging or other radio signal
- A fault or abnormal condition
- Other initiating conditions
- A combination of the above

If a charge free telephone number is used (such as a British Telecom 0800 number) then the customer will receive no additional telephone charges. If the automatically generated call is made in the night, then the customer probably will not notice the additional telephone use. As the line may be a dial-out only line, then the electricity meter is unlikely to generate any additional load (sometimes described as R.E.N.) on the telephone line. This means that modifications at the telephone exchange are unlikely to be required. Modifications at the customer's premises are also likely to be small.

Billing information may also be transferred by:

A manually established telephone call
A radio system
The system LCD display
An electrical data connection to which portable reading equipment may be fitted
An optical signalling device which transfers data to portable reading equipment

Gas Heating & Metering Systems

This technology may be adapted for use with Gas heating and metering systems.

The system would allow variable rates to be charged, depending on the time of day. Rates and times would be broadcast over the radio-paging network. Signals to gas using equipment could be used to reduce demand for gas when overall gas demand may be high.

Similarly the technology could be used for water metering systems.

5.0] Detailed Description of System

This section describes primarily a system for controlling storage heaters. Electricity metering applications are also considered.

Firstly the Central Control Unit, which is an essential component of all Wide Area Control systems is described. This is then followed by a description of the optional temperature sensors and baffle controllers. Section 5.4 discusses the Control Algorithms used by the system with the final sections covering Public Paging Networks and the European Control Centre. Block Diagram Figure 2 which shows all elements of the Wide Area Control system should be referred to.

5.1] Central Control Unit

The Central Control Unit is wall-mounted and is connected so that the power supply to the storage heaters is wired through it. Block Diagram Figure 3 should be referred to. The Control Unit is micro-processor based and fitted with a user display and keypad for programming. It has an integral radio paging receiver for receiving information from the European Control Centre. The Central Control Unit also has a 418MHz transmitter and receiver for communications with local temperature sensors and with storage heater baffle controllers. The individual modules of the Central Control Unit are described below:

Power Supply Unit

The Central Control Unit will operate on a DC supply (nominally 9V). This will be from a rechargeable battery which will be charged by a transformer/rectifier unit from the incoming 240V AC supply (not the output supply). The input to the transformer will be electrically protected (e.g. fused) to make the unit safe and compliant with required electrical approvals. The battery will be replaceable and will be supplied fully charged. It will be fitted as part of the Central Control Unit installation procedure. The battery will have adequate capacity to drive the Central Control Unit for 50 hours without charging. The table below shows power usage of the various modules within the Central Control Unit.

	Current (mA) in use	Usage (%)	Current (mA) in standby	Current (mA) mean overall
Microcontroller	3.0	2%	0.005	0.065
LCD Display	0.03	100%	N/A	0.03
Paging Receiver	1.2	25%	0.01	0.31
418 MHz Receiver	1.2	100%	N/A	1.2
418 MHz Transmitter	10.0	0.1%	0.01	0.02
TOTAL				**1.6mA**

5.1] Central Control Unit (continued)

Battery capacity should therefore be 50Hrs x 1.6mA = 80mAH. A standard Nickel Cadmium PP3 rechargeable 9V battery will be used as it has a capacity of 120 mAH. The specified charging rate for such a battery is 12mA. This means that the battery could receive a charge of up to 7Hrs x 12mA = 84mAH over the 7 hour cheap rate period.

Paging Receiver

The paging receiver will receive the paging data and pass this serial data to the micro-controller. The paging receiver is capable of receiving data from a number of different paging networks (e.g. BT, Mercury, Netherlands PTT).

The receiving network and pager number can be changed by the micro-controller, with the receiver having memory to determine what its frequency and pager number is. The receiver has a buffer to store incoming message strings before they are passed to the micro-controller. The receiver has the following specifications:

Paging Network:	Determined by Radio Frequency
Receive Frequency:	Determined by Micro-Controller
Communications Standard:	POCSAG and MPT1305
Pager Number:	Determined by Micro-Controller
Comms to Controller:	Interrupt; Serial Data; Receive Signal
Comms from Controller:	Serial Data; Frequency Select; Number Select

The BT paging network has a protocol which requires that the pager receives for only 25% of the time, reducing receiver circuit power requirements.

The receiver is specified to have re-configurable network and number so that the controller is flexible and only one type of controller has to be produced. If this approach proves to be too expensive then a possible alternative is to supply the paging unit as a plug-in module which can be changed to suit the network and pager number. (It could also be fitted with DIP switches).

Local Radio Data Receiver

This 418 MHz Receiver receives coded data from temperature sensors located inside and outside the house. Radio communication is to the MPT1340 standard meaning that no individual licence is required. Received radio data is passed to the microcontroller. The received binary data-string has the following structure:

HHHHHCCCCCCCCIIIIITTTTTTTTEEE

The table on the following page shows how the bit-pattern above is derived. In the example shown in the table [Table 2] the received bit-string would be as follows:

00101 10111110 00001 01100100 010

5.1] Central Control Unit (continued)

Local Radio Data Receiver (continued)

Identifier	Description	Encoding	Example
HHHHH	Preamble associated with Wide Area Control System	Constant	00101 Temperature 00110 Baffles
CCCCCCCC	Identifier set uniquely for customer to prevent interference with neighbouring systems.	Set initially at manufacture. Can be changed if necessary.	10111110
IIIII	Individual temperature sensor Identifier.	Determined by particular sensor broadcasting message.	00001
TTTTTTTT	Transmitted Temperature 0-255	00000000 0 = -30C 11001000 200= 70C	01100100 = 20C
EEE	Error Checking	CRC method	010

Table 2

The Local Receiver has the following specifications:

Radio Frequency: 418MHz
Modulation Type: FM (25KHz Modulation)
Antenna Type: Helical
Approval Standard: MPT1340
Comms to Controller: Interrupt; Serial Data

Local Radio Data Transmitter

The Transmitter is also MPT1340 compliant and is used to transmit data to the storage heater baffle controllers. The transmitted preamble (shown as HHHHH above) is different from received preambles so that transmissions can be distinguished. The transmitted bit pattern has a similar structure with parameters as defined in the table on the following page. The Local Transmitter has the following specifications:

Radio Frequency: 418MHz
Modulation Type: FM (25KHz Modulation)
Antenna Type: Helical
Approval Standard: MPT1340
RF Power Output: 0.25mW
Comms to Controller: Serial Data; Transmit enable signal

5.1] Central Control Unit (continued)

Local Radio Data Transmitter (continued)

Identifier	Description	Encoding	Example
HHHHH	Preamble associated with Wide Area Control System	Constant	00110 Baffles 00101 Temperature
CCCCCCCC	Identifier set uniquely for customer to prevent interference with neighbouring systems.	Set initially at manufacture. Can be changed if necessary.	10111110
IIIII	Individual Baffle Controller Identifier.	Dependant on Baffle Controller to be addressed.	00001
TTTTTTTT	Required level of Baffle opening.	00000000 0 = Closed 00000111 7 = Open	00000110 = 6 (Nearly fully open)
EEE	Error Checking	CRC method	010

AC Supply Contactor

The contactor switches the mains supply to the storage heaters. It only has to operate when there is an incoming supply to the storage heater circuit (i.e. during the cheap-rate period when the supply is live). It is operated to allow the storage heaters to charge. The contactor has the following specification:

Type: Single Pole, Normally Open
Contact Rating: 100A
Coil Rating: 9V DC
Coil Impedance: 60 Ohm (approx.)
Power Supply: 250V AC Single Phase

The contactor will have a transistor circuit to drive the relay coil. This will be operated by a Power-On output from the Micro-Controller.

LCD Display

The LCD display will be driven from the Micro-Controller and will be used:

- For programming the Controller with temperature requirements, geographic location and house temperature characteristics
- For displaying Time, Weather Forecast and Power Consumption Information

5.1] Central Control Unit (continued)

LCD Display (continued)

The LCD Display has the following specifications:

Size:	2 x 20 Characters
Resolution:	5 x 7 Dots per Character
Type:	Display with Integral Controller and RAM
Consumption:	0.03mA
Comms from Controller:	Direct Addressing

Keypad

The Keypad is used for programming the controller and selecting required displays. It has 8 keys and is of a membrane type. The ON key is used to give an interrupt to the controller. The remaining keys are polled using two logical outputs and three logical inputs.

Micro-Controller

The Micro-Controller consists of the following:

Micro-Processor
ROM (containing operating program, controller unique ID)
RAM (static and dynamic)
Clock
I/O (Interrupts, Serial Input, Serial Output, Logic In, Logic Out, Direct Addressing)

It is intended that the Micro-Controller will be based on a single chip which incorporates the above sub-components.

The Micro-Controller has two modes of operation: Operation and Standby. Interrupts cause the Micro-Controller to change from Standby to Operational mode. The Micro-Controller reverts back to Standby mode on completion of processing. It is estimated that the system will be in Operational mode for 2% of the time. For the remainder of the time it will be in Standby mode.

The following events will cause changeover to Operational mode:

- Receipt of a valid paging signal
- Receipt of a Local Radio Data Receiver signal
- Depression of the Keypad ON Key
- Energisation of the incoming AC supply

The Micro-Controller will process the above signals and then return to Standby mode. Power Consumption in Standby mode is lower than in Operational mode.

5.2] Temperature Sensors

Refer to Block Diagram Figure 4 for details. The Power Saving Timer Circuit energises circuits for a short period every 20 minutes, so that the temperature can be sampled and transmitted. The processor sends a signal to the timer circuit on completion of the process.

5.3] Baffle Control Unit

Refer to Block Diagram Figure 6 for details.

5.4] Control Algorithms

Refer to Temperature Control System Variables document Table 1.

The contactor closed time is calculated based on the following:

Regional Weather Forecast Data
Programmed House and Heating System Thermal Characteristics
Programmed desired comfort/temperature levels
Local temperature sensors
Calculated existing storage brick temperatures

Contactor actual close and open signals are based on the following:

Contactor Closed Time
ESI Demand Management signals
Mode of Operation
Econ 7 start and stop times
Actual Time
Random number generator

With no ESI Demand Management signals the probability of the Contactor being closed at any time during the Econ 7 period will be constant. It is planned that the storage heaters will be energised for an average of three periods over the Econ 7 cheap-rate period. The standard time interval used by the control system will be ten minutes.

5.5] Public Paging Networks

The Public Paging Network will be used to send three types of signal to the Control Units. All signals will be sent from or via the European Control Centre. The signal types are:

- Regional Weather Forecast signal
- ESI Demand Management signal
- Individual Maintenance or Customer Service signal

The system will be developed so that it can be easily configured to run on a number of different paging networks.

5.6] European Control Centre

Refer to Block Diagram Figure 5.
The European Control Centre equipment processes all messages to be transmitted via the Paging System. This would in effect be a PC with Software which drives a telephone dialler and automatically makes paging calls to the telephone network using DTMF tones. Paging network access is also available via modem links with the Paging Network Operator.

A separate monitoring system is used to receive and monitor transmissions. This ensures that:

All messages that are passed for broadcast are actually broadcast by the Paging Network Operator

All messages are valid and correct

No invalid messages are broadcast or sent erroneously by other sources

6.0] Meteorological Data and Weather Forecasts

Meteorological Data will be obtained from the following sources:

- Via Compuserve and other data providers
- Via Teletext
- From the Met office directly
- Other Information Providers

7.0] Electricity Supply Industry Demand Control

Electricity Trading

In England and Wales Electricity is traded through a market called the Pool. The day is divided into 48 half-hour time slots and there is a price and a level of demand for each time-slot. The price can vary quite considerably between individual time-slots. Under these conditions it is usual for supply to follow demand. Generation is scheduled to meet forecast demand, and standby generation is available to meet excess demand and cover for failure of other generating plant.

Demand Control

If a Wide Area Control system has to be on for a shorter period than the full cheap-rate electricity period (this will nearly always be the case) then the customer is not particularly concerned when the supply is on and when the supply is off, so long as the total time on is correct and as calculated. This means that at any particular time the supply can be either on or off without affecting the performance of the heating system. It is this principle upon which the Demand management feature is based.

Each Wide Area Control Central Control Unit has a unique identifier which is used for load management purposes. The Control Centre sends out load management signals to switch on or off groups of storage heaters simultaneously. With many homes fitted with Wide Area Control systems large (Thousands of MegaWatts) load swings can be initiated instantaneously. The table below shows the level of load control available for various situations (simplified).

Example	1	2	3	4	5	6
On-Time (Hrs)	1.0	3.5	6.0	1.0	3.5	6.0
No. Homes ('000s)	200	200	200	3000	3000	3000
Heating Sys Rating (kW)	10	10	10	10	10	10
Max. Load Rejection (MW)	285	1,000	1,715	4,285	15,000	25,725
Max. Load Addition (MW)	1,715	1,000	285	25,725	15,000	4,285

It can be seen that under favourable conditions up to 25,000 MegaWatts or 25 GigaWatts of load can be switched simultaneously. This is equivalent to the output from twenty modern power stations!

7.0] E.S.I. Demand Control (continued)

The demand control is variable in the order of KiloWatts as load control signals can be sent to between one and all installed Wide Area Control systems.

8.0] Generation Control

Control data may be broadcast to an electricity generator. This data may be broadcast over a radiopaging network or a public radio data network, such as the *Paknet* system in the United Kingdom. Control data may include electricity price data or tariff data. The generator may operate when electricity prices are high, but not when prices are lower. Data such as operational data, metering data or maintenance data may be retrieved. Alarm data may be retrieved should a generator fail to start.

This data may be read over the radio data network or an alternative communications channel such as a telephone line. Figure 8 shows a generator control system where the broadcast medium is a radio data network.

9.0] Further Developments and Products

- Remote Control of Heating Systems using automated telephone calls to the European Control Centre (incl. Gas & Oil Systems)
- Stand-Alone pager controlled circuits and data-links
- Integration of European Control Centre with another service (Weather, ESI, Paging, 0891 Weather Line etc.)
- Frost Warning: Switch on Pond and Outhouse heaters. Audible or Visual alert for drivers. Other Bad Weather alerts

Claims

1] A control system comprising a control centre which broadcasts control signals and receiving equipment which initiates control of devices responsive to the control signals.

2] A control system as described in Claim 1 wherein a plurality of control centres broadcast control signals.

3] A control system as described in Claim 1 or Claim 2 wherein the controlled devices include energy means.

4] A control system as described in Claims 1,2 or 3 wherein the control signals are broadcast on a radio medium.

5] A control system as described in Claim 4 wherein the radio medium is a two-way radio data network.

6] A control system as described in Claim 5 wherein the control centre receives retrieved data from a controlled device via the radio medium.

7] A control system as described in Claim 6 wherein the retrieved data is operational information data or energy consumption data or energy production information data.

8] A control system as described in Claim 4 wherein the radio medium is a radiopaging network.

9] A control system as described in Claim 8 wherein the radio medium is more than one radiopaging network.

10] A control system as described in any one of Claims 1 to 9 wherein the control signals include variable parameters.

11] A control system as described in any one of Claims 1 to 10 in which the receiving equipment comprises a plurality of receivers.

12] A control system as described in Claim 11 wherein each receiver is associated with at least one device, each receiver and at least one associated device being situated at different geographic locations.

13] A control system as described in Claims 11 or 12 wherein the control signals are encoded to initiate responses from all receivers or at least one of their respective associated devices.

14] A control system as described in Claims 11,12 or 13 wherein the control signals are encoded to initiate responses from a specific receiver or at least one of its respective associated devices.

Wide Area Control System

Claims

15] A control system as described in any of Claims 10 to 14 wherein the control signals are encoded to initiate responses from a specific group of receivers or at least one of their respective associated devices.

16] A control system as described in any of Claims 3 to 15 wherein the controlled devices include means for the use of electricity.

17] A control system as described in any of Claims 3 to 16 wherein the controlled devices include means for the generation of electricity.

18] A control system as described in any one of Claims 3 to 17 wherein the controlled devices include means for the metering of electricity.

19] A control system as described in any one of Claims 3 to 18 wherein the controlled devices include means for the use of gas.

20] A control system as described in any one of Claims 3 to 19 wherein the controlled devices include means for the metering of gas.

21] A control system as described in Claims 16,17 or 19 wherein the controlled devices include heating means.

22] A control system as described in Claim 16 wherein the controlled devices include refrigeration means.

23] A control system as described in Claim 16 wherein the controlled devices include ventilation or air-conditioning means.

24] A control system as described in Claim 21 wherein the controlled devices include means for heating and for electricity generation.

25] A control system as described in Claim 21 wherein the controlled devices are associated with at least one storage heater.

26] A control system as described in Claims 16,17,19,21,22,23,24 or 25 wherein the controlled devices are switched on or off responsive to the control signals.

27] A control system as described in Claims 16,17,19,21,22,23,24,25 or 26 wherein responsive to the control signals the receiving equipment initiates a change in the rate of energy use or generation by the controlled device.

28] A control system as described in any one of Claim 1 to 27 wherein the control signals include energy price data.

29] A control system as described in any one of Claims 1 to 28 wherein the control signals include meteorological data.

Wide Area Control System

Claims

30] A control system as described in Claim 28 when dependent on Claim 18 or Claim 20 wherein the controlled device includes means for automatically calculating the cost of energy used.

31] A control system as described in Claim 28 when dependent on Claim 26 or Claim 27 wherein the response of the controlled device is dependent on the energy price data.

32] A control system as described in any one of Claims 16 to 31 wherein the controlled device is energised for a variable length of time.

33] A control system as described in Claim 28 wherein the controlled devices include means responsive to the energy price data to automatically reduce the cost of energy consumption or increase profit from generation whilst ensuring that the controlled devices perform their required functions.

34] A control system as described in Claim 32 wherein the length of time for which controlled devices are energised is calculated automatically based on the control signals.

35] A control system as described in Claim 34 when dependent on Claim 29 wherein the length of time for which controlled devices are energised is calculated automatically based on the meteorological data.

36] A control system as described in any one of Claims 25 to 35 wherein the controlled device operates a contactor which switches an electrical supply to at least one storage heater.

37] A control system as described in Claim 36 wherein the controlled device has a local interface allowing contactor operation to be controlled by the control signals and local data input.

38] A control system as described in any one of Claims 25 to 37 wherein the controlled devices are storage heaters fitted with automatically activated baffles that allow control of the rate of heat discharge.

39] A control system as described in Claim 38 wherein the baffles are automatically controlled to maintain a required temperature.

40] A control system as described in any one of Claims 16 to 21 wherein the controlled devices can initiate return of data to the control centre via an alternative communications system.

41] A control system as described in Claim 40 wherein the controlled devices may initiate return of data via a telephone circuit.

Wide Area Control System

Claims

42] A control system as described in Claim 40 or Claim 41 wherein the controlled devices may initiate return of data via a communications circuit which has at least one other function.

43] A control system as described in Claims 40,41 or 42 wherein the returned data is energy consumption data or cumulative cost data.

The Patent Office

3.

Application No: GB 9701620.8 **Examiner:** Mike Davis
Claims searched: 1-43 **Date of search:** 8 April 1997

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Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): G4H (HNEC,HNEE,HNEL,HNEM)

Int Cl (Ed.6): H04Q

Other:

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2282686 A	(RICHARDSON)	1 at least
X	GB 2198269 A	(MULTITONE)	"
X	EP 0265342 A2	(SANGAMO WESTON)	"
X	WO 93/02515 A1	(IRIS SYSTEMS)	"
X	US 4517562	(MARTINEZ)	"
X	US 4454509	(BUENNAGEL ET AL)	"

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.